NRI research highlights

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Use of Urea-Based Fertilizers to Stimulate Plant Growth

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All crops require nitrogen for growth and reproduction. Some plants, such as soybeans and other legumes, establish a symbiotic association with a microorganism that is able to convert nitrogen gas from the atmosphere into a usable nitrogen source. This process is called "fixing" nitrogen.

Most plants, however, cannot fix nitrogen. They must instead use nitrogen that is already fixed in the soil. Plant growth will be limited when the soil does not contain enough nitrogen. For this reason, many crop farmers use fertilizers containing nitrogen to increase productivity.

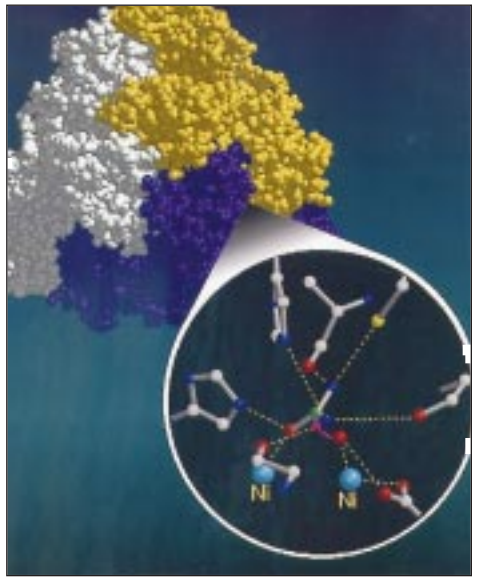
Urea in Fertilizers

A chemical compound called urea is widely used in fertilizers (see diagram on back) because of its high nitrogen content, low cost, and ease of handling. Urea is produced naturally by livestock and other animals, as well as by many plants and microorganisms.

The usefulness of urea depends on its breakdown into two molecules of ammonia and one of bicarbonate. This chemically difficult reaction is aided by the enzyme urease, which is present in many soil bacteria.

The timing of this breakdown is crucial. If the urea breaks down too quickly, the released ammonia makes the soil alkaline (and therefore toxic to many plants), and the ammonia evaporates. On the other hand, if the urea breaks down too slowly, it may not stimulate plant growth.

Researchers are looking for ways to control soil urease activity to break down urea at a rate that optimizes fertilizer efficiency. One effective approach is to mix urease inhibitors with fertilizer. The devel-



The structure of urease as determined by crystallographic analysis. The expanded portion of the figure illustrates the nickel-containing catalytic site.

Graphics by Matt Slaybaugh.

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opment of such specific inhibitors requires basic research on the properties of bacterial urease.

Understanding Urease

USDA's National Research Initiative (NRI) Competitive Grants Program is supporting basic research at Michigan State University and at Oregon State University to better understand the structure of urease and the ways in which the enzyme works to break down urea.

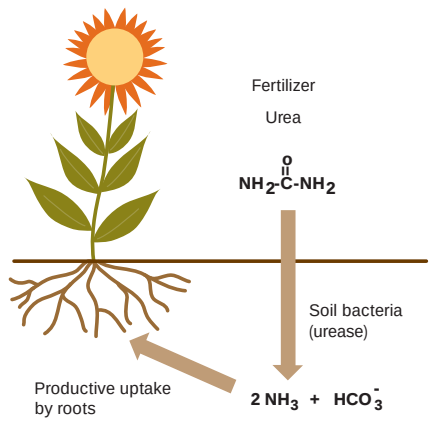
One area of study focuses on urease that has been isolated from a bacterial source. A second emphasis involves study of urease that has been isolated from jack bean seeds. Both the bacterial and plant proteins are closely related in amino acid sequence, and – as demonstrated by x-ray crystallographic techniques – in their three-dimensional structures.

The bacterial urease structure (see photo on front) shows a tightly folded unit that contains three novel nickel-containing catalytic sites. Each site has two nickel ions that are bound to the protein and properly positioned by a distinct set of amino acid residues. An essential protein side chain, which bridges the two metal ions, is a modified form of a normal amino acid – a lysine carbamate.

Researchers are also studying possible ways in which this novel nickel-containing enzyme aids in the breakdown of urea. From structural and enzymatic data the researchers developed a dynamic model for the action of the enzyme. They also generated and studied modified forms of the protein by site-specifically altering the DNA encoding the enzyme. By understanding the structure of the enzyme, particularly in an inhibited state, they can design and test new urease inhibitors. These inhibitors, when mixed with urea fertilizers, will permit breakdown of urea at a rate optimal for nitrogen uptake by plants.

With NRI funding, scientists are making significant progress in understanding the structure, mechanism, and inhibition of urease. Greater knowledge of the enzyme is expected to lead to the development and marketing of more effective, efficient forms of fertilizer. This should result in higher crop yields, as well as lower costs for both producers and consumers.

PLANT ROOTS ABSORB NITROGEN FROM AMMONIA (NH_3), WHICH IS RELEASED AS SOIL BACTERIA THAT CONTAIN UREASE BREAK DOWN THE UREA FOUND IN MANY FERTILIZERS.



The research reported in this factsheet was sponsored by the Nitrogen Fixation/Nitrogen Metabolism Program of the Plants Division of the National Research Initiative Competitive Grants Program. To be placed on the mailing list for this publication or to receive additional information, please contact the NRI (202/401-5022 or NRICGP@reeusda.gov). The factsheet is accessible via the NRI section of the Cooperative State Research, Education, and Extension Service website (www.reeusda.gov/nri).